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14. ABSTRACT

One area in which the U.S. and DoD has a growing need for talent is in computer science. These STEM professionals play an important role in technologies, systems design, and software development. The Department of Labor has projected that in ten years, the demand for these STEM professionals will be 24 percent higher than it was in 2008. At the same time, we do not have a sufficient number of students seeking degrees in these fields, especially those that are female and are U.S. citizens. This is an important issue for DoD. We must rely on U.S. citizens for our workforce. Interventions proposed include implementing high-quality computer science education more actively at the high school level.

15. SUBJECT TERMS

education, outreach, computing, STEM, k-12

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Presentation slides from the U.S. Department of Defense Science, Technology, Engineering and Mathematics (STEM) Summit October 18, 2010

Coordinated by the
DoD DDR&E STEM Development Office
703-588-1405 / STEM@osd.mil

Department of Defense
Defense, Research and Engineering

Welcome to the

DoD STEM Quarterly Meeting

18 October 2010

Computing Education

- Increase in computing needs in labs
- Foundation for other STEM disciplines
- Vital to complex engineering
- Digital learning technologies
- Changing teaching needs, methods and courses

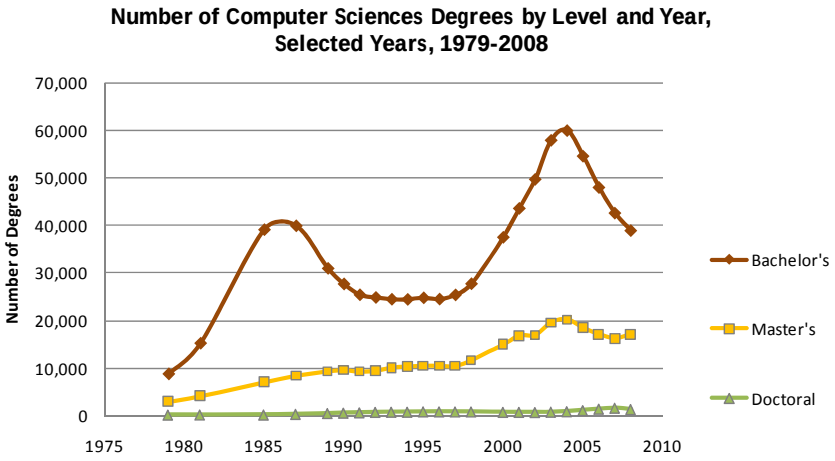
Demographic Overview of Degrees Awarded in Computer Science

Lisa M. Frehill
Senior Analyst, Energetics Technology Center
Director of Research, Evaluation, and Policy, NACME
October 18, 2010

Data Notes

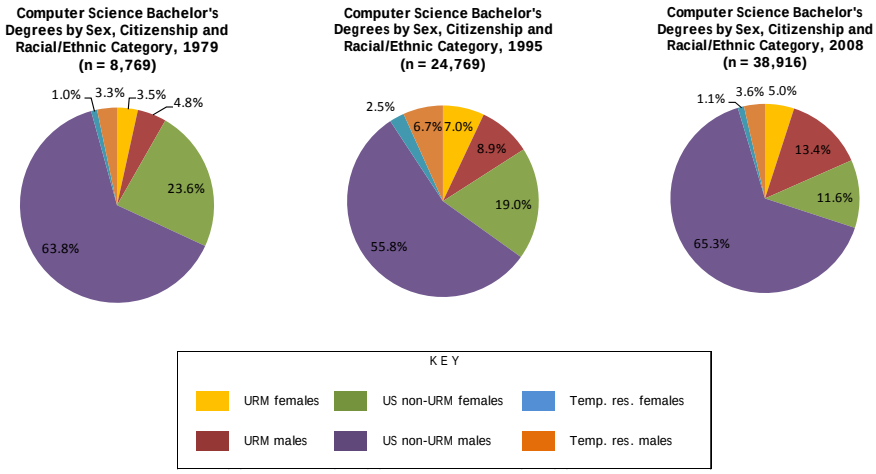
- IPEDS = Institutional Postsecondary Educational Data System
- Collected annually by National Center for Education Statistics for all Title V institutions (those that receive Federal funds – virtually all U.S. colleges and universities).
- WebCASPAR = database system maintained by the National Science Foundation – enables access to IPEDS data as well as a number of other data collections.
- Citizenship and Racial/Ethnic Categories:
  - U.S. = U.S. Citizens and Permanent Residents
  - Temp. Res. = Temporary Residents (a.k.a. "foreign students")
  - URM = underrepresented minority, includes Black, Non-Hispanic; American Indian/Alaska Native; and Hispanic.
  - US non-URM = all other U.S. citizens and permanent residents NOT in the three URM categories. This includes Asian, White, and Other or Unknown race/ethnicity.

Trend in computer science degrees – steady increases at graduate levels but unevenness at undergraduate.



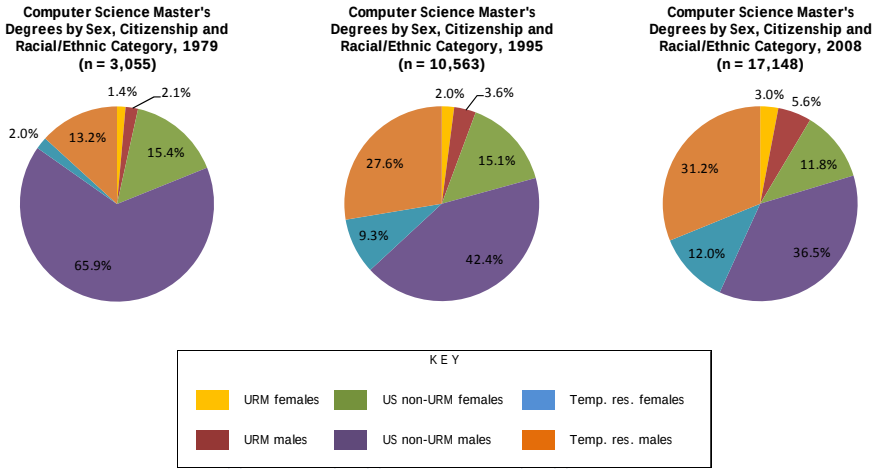
Source: Energetics analysis of IPEDS data accessed via National Science Foundation WebCASPAR database, October 8, 2010.

Bachelor's Degrees in Computer Science, 1979, 1995, 2008



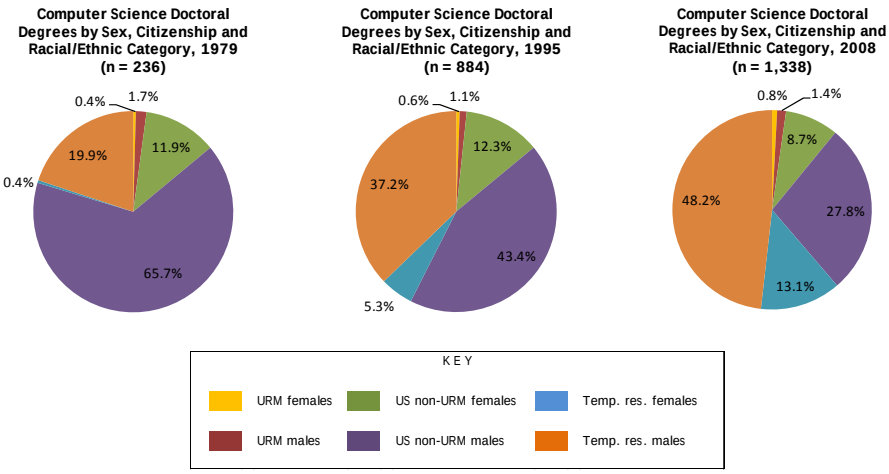
Source: Energetics analysis of IPEDS data accessed via National Science Foundation WebCASPAR database system, October 8, 2010.

Master's Degrees in Computer Science, 1979, 1995, 2008



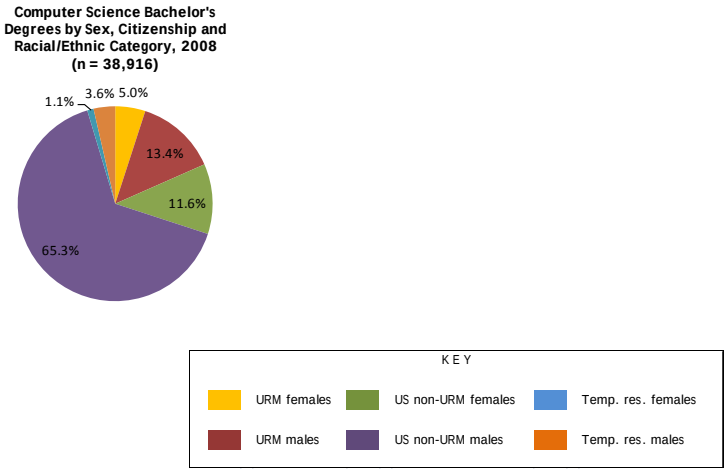
Source: Energetics analysis of IPEDS data accessed via National Science Foundation WebCASPAR database system, October 8, 2010.

Doctoral Degrees in Computer Science, 1979, 1995, 2008



Source: Energetics analysis of IPEDS data accessed via National Science Foundation WebCASPAR database system, October 8, 2010.

Degrees in Computer Science by Level, 2008



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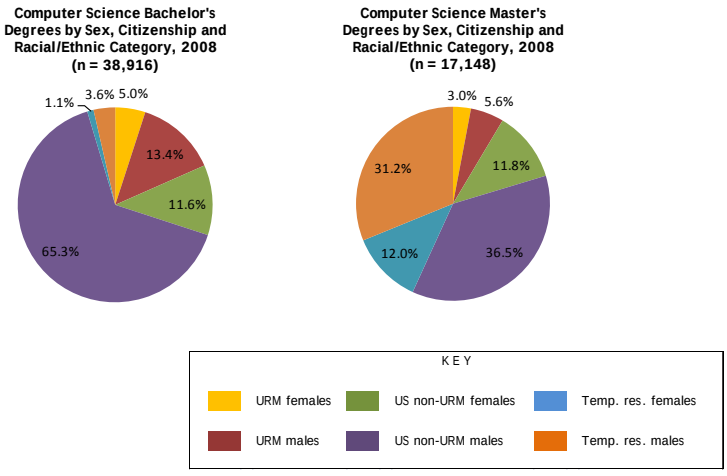

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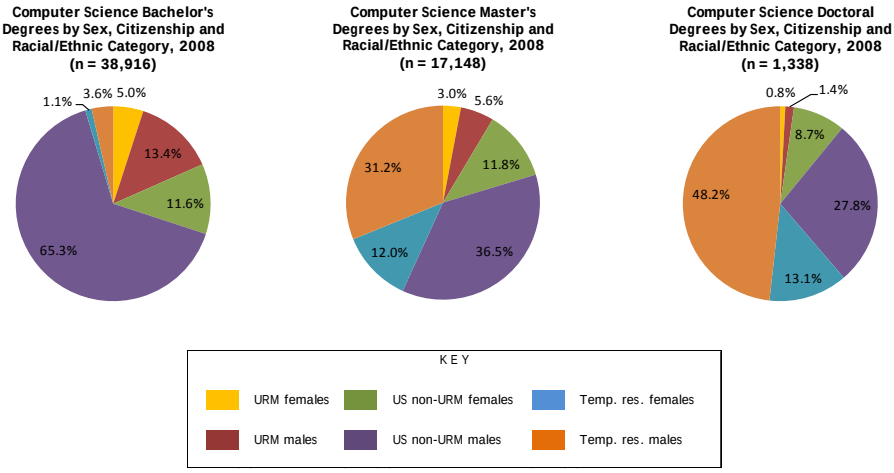
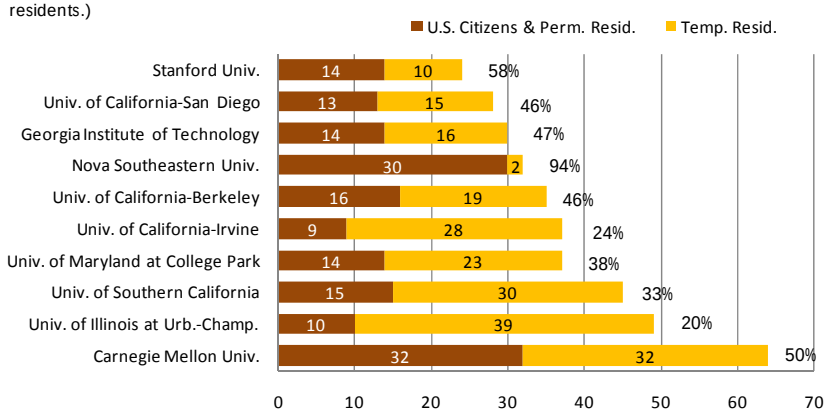


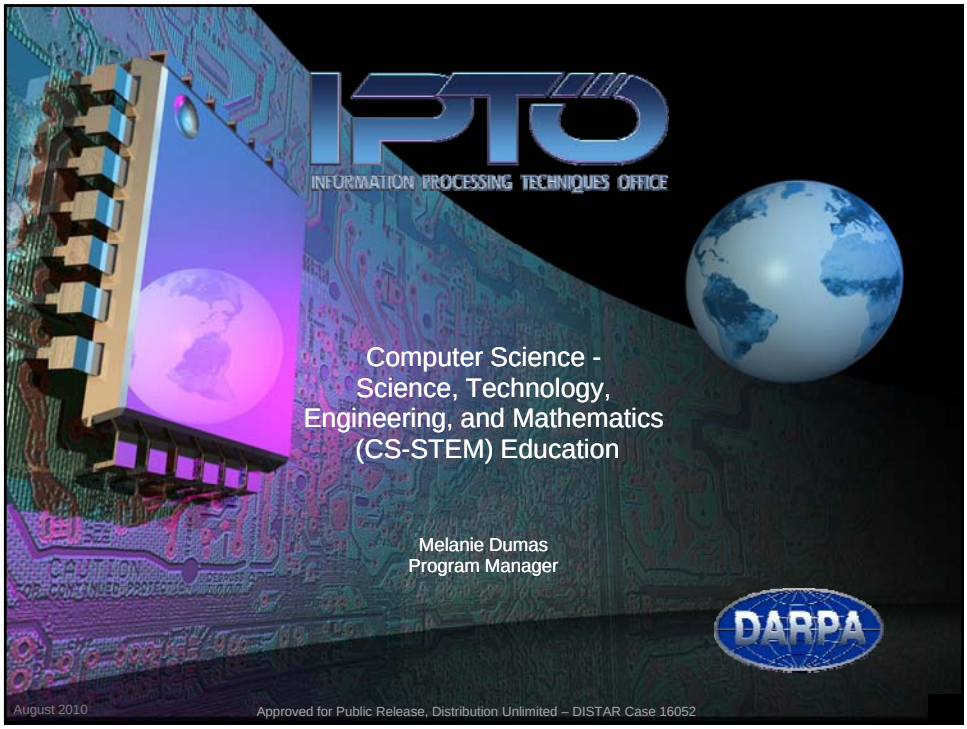
Source: Energetics analysis of IPEDS data accessed via National Science Foundation WebCASPAR database system, October 8, 2010.

Half of the top 10 producers of computer science doctoral degrees are in California – large variation in percent of awards to U.S. citizens and permanent residents.

Number of Doctoral Degrees by Citizenship Status at Top 10 Producers of Computer Science Doctoral Degrees, 2008
(Also shown: percent of all doctoral degrees awarded to U.S. citizens and permanent residents.)



Source: Energetics Technology Center analysis of IPEDS data accessed via National Science Foundation's WebCASPAR database system, October 8, 2010.



The Opportunity: Lots of Jobs

Fastest growing US occupations, 2008 and projected 2018 (Bureau of Labor Statistics)
Rank ordered by number of projected new jobs over ten years (Numbers in thousands)

2008 National Employment Matrix title and code	Major occupational group	Employment 2008	Employment 2018	Change, 2008-2018 Number	Change, 2008-2018 Per cent	Median Annual wage quartile 08	Most significant source of postsecondary education or training
Home health aides	Service	921.7	1382.6	460.9	50.0	Very Low	Short-term on-the-job training
Personal and home care aides	Service Mgmt, business	817.2	1,193.0	375.8	46	Very Low	Short-term on-the-job training
Computer software engineers, applications	Professional and related	514.8	689.9	175.1	34.0	**Very High**	Bachelor's degree
Medical assistants	Service	483.6	647.5	163.9	33.9	Low	Moderate-term on-the-job training
Network systems, data comm. analysts	Professional and related	292	447.8	155.8	53.3	**Very High**	Bachelor's degree
Computer software (SW) engineers, systems SW	Professional and related	394.8	515	120.2	30.4	**Very High**	Bachelor's degree
	Total	**5432.1**	**6893.8**	**1451.7**			
	CS/CE related	**1201.6**	**1652.7**	**451.1**	**38%**		
	CS/CE % of total	**22%**	**24%**	**31%**			

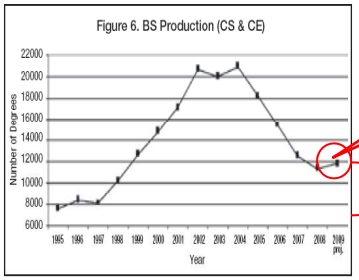
Three of the top six job creating fields are CS/CE related

The highest paying jobs of the top six are all CS/CE related

31% of job creation in top 30 fields belongs to CS/CE!

...with high projected growth... ~45,000 jobs per year!

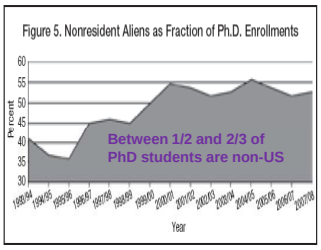
The Problem: We are losing ability to fill them.



>45000 Needed!

<12000 produced

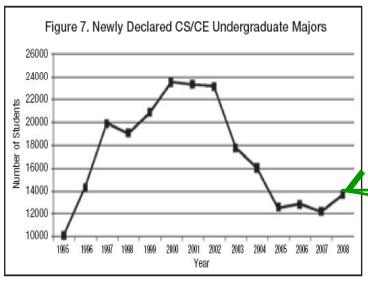
Almost half of these degrees are to foreign students



According to NSF:

- 41,540 foreign students were enrolled in CS in 2008.
- ~50% of these were undergraduate
- ~27% of these are in a given year
- From this we estimate ~ 5536 foreign students are enrolled in CS annually
- Given 14,000 newly declared majors, ~40% are foreign students

http://www.nsf.gov/statistics/infbrief/nsf10324/#tab1

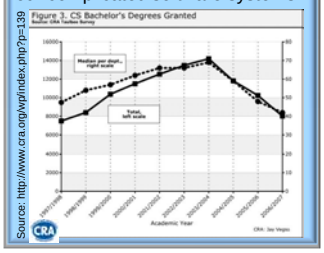


Need to turn a positive step…

…into a trend…

Computer Science, Science, Technology, Engineering, and Mathematics (CS-STEM) Education Program

National Problem:
Fewer graduates with computer science degrees cannot support our complicated software systems



Goal: Increase the number of college graduates with CS-STEM degrees

Challenging Student Activities:

- Provide compelling, age appropriate CS-STEM student activities
- Work with the students from middle school through high school for a long term, positive impact
- Couple student activities with the classroom to encourage CS-STEM elective and major selection
- Stretch to make a nationwide impact, including reaching out to disadvantaged, women, and minority under-represented groups

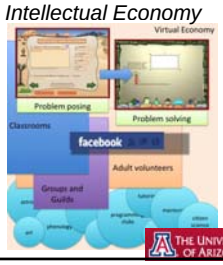
Robust Organizational Support:

- Provide a sustainable infrastructure to support Student Activities
- Monitor student population size to ensure long-term growth
- Recognize best practices for an adaptable organization

Status:

- 3 Performers
- Kickoff Aug 2010

Intellectual Economy



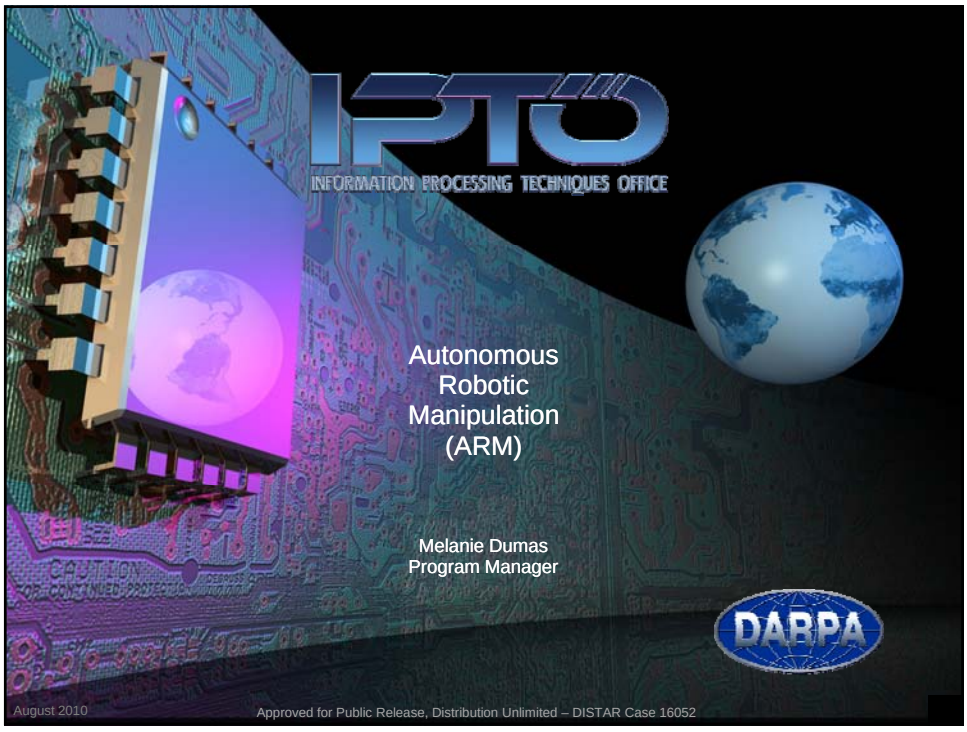
Software Competitions

Robotics Competitions

Metrics

	Phase 1: Performance Metrics
Continuity	Provide comprehensive, challenging activities from middle school through high school. Provide formal structure to encourage students to select CS-STEM academic coursework.
National Presence	At least one student participating from at least 15 of the United States
Sustainability	Goals stated in the detailed Sustainability Plan are being met

	Phase 2 and 3: Performance Metrics
Continuity	Provide comprehensive, challenging activities from middle school through high school. Provide formal structure to encourage students to select CS-STEM academic coursework.
National Presence	Number of students enrolled in the project increases 20% from the previous year, with at least one student participating from 15 of the United States
Sustainability	Goals stated in the detailed Sustainability Plan are being met.
	Retention: At least 80% students continue with the activities from the previous year



ARM Program Motivation

We put people in danger every day, because sometimes hands are the only tools that work -- particularly in situations that need high resilience, flexibility, and adaptability.

The ARM program will enable military applications that can revolutionize the battlefield by making robots just as dexterous, resilient, and flexible.

Autonomous manipulation with a pair of mechanized arms/hands enables effective unmanned applications

Technical Challenge

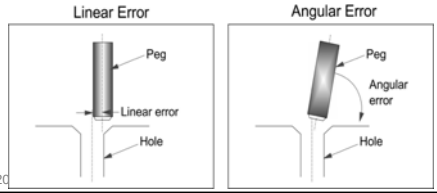
Manipulation requires many degrees of freedom (dof), and the results of contact are inherently unpredictable

Dimensionality

- Car 2-dof (steer, accelerate)
- BigDog 16-dof (4 x 4-dof legs)
- Pick Up Pen 32-dof

Contact Models

- Newton's laws can predict the outcome of physical interactions – Seems easy
- But motions are not performed or known exactly, so geometry is uncertain
- And forces are not applied exactly, so dynamics are uncertain
- And material properties (friction, stiffness) of real objects not uniform or well-known
- Soon, error bars swamp the knowns – Not so easy anymore!



Uncertainty is the key issue
Adaptability is key

Collaboration Option: Write Software to control the ARM robot

ARM Autonomous Robotic Manipulation

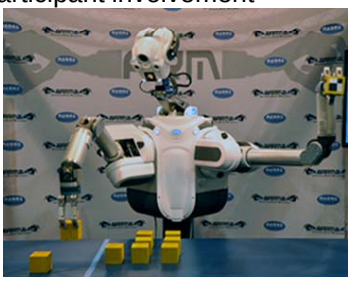
http://www.theARMrobot.com

About the Robot Participate Name the Robot Media

DARPA is introducing its **Autonomous Robotic Manipulation** (ARM) program. The goal of this 4 year, multi-track program is to develop software and hardware that allows an operator to control a robot which is able to autonomously **manipulate, grasp and perform complicated tasks**, given only high-level direction. Over the course of the program in the Software Track, funded performers will be developing algorithms that enables the DARPA robot to execute these numerous tasks. DARPA is also making an identical robot available for public use. Allowing anyone the opportunity to write software, test it in simulation, upload it to the actual system, and then watch, in real time via the internet, as the DARPA robot executes the user's software. Teams involved in this Outreach Track will be able to compete and collaborate with other teams from around the country.

Outreach Track

- In addition to the core ARM research program, DARPA will sponsor an Outreach Track
  - Opportunity for unfunded, external participant involvement
  - DARPA provides:
    - Hardware
    - Interface for remote development
    - Test environment
    - Technical support
  - Targeted participants
    - Students/educational institutions
    - Average citizen/hobbiest
    - Interested corporate teams

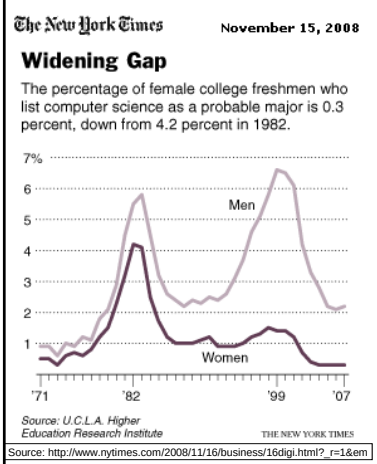


- **General participant outreach**
  - Global usage of user-developed code in identical ARM test environment
  - Opportunity for general community to develop code similar to funded teams
  - Focused public events (FIRST-type competitions)
- **Artistic outreach**
  - Museum events for general community use (e.g. creation of “techno-art”)
  - Ability to see technology and result in a public forum

WATCH FOR MORE UPCOMING DARPA EDUCATION PROGRAMS!

Backup

Women and CS



Source: http://www.nytimes.com/2008/11/16/business/16digi.html?_r=1&em

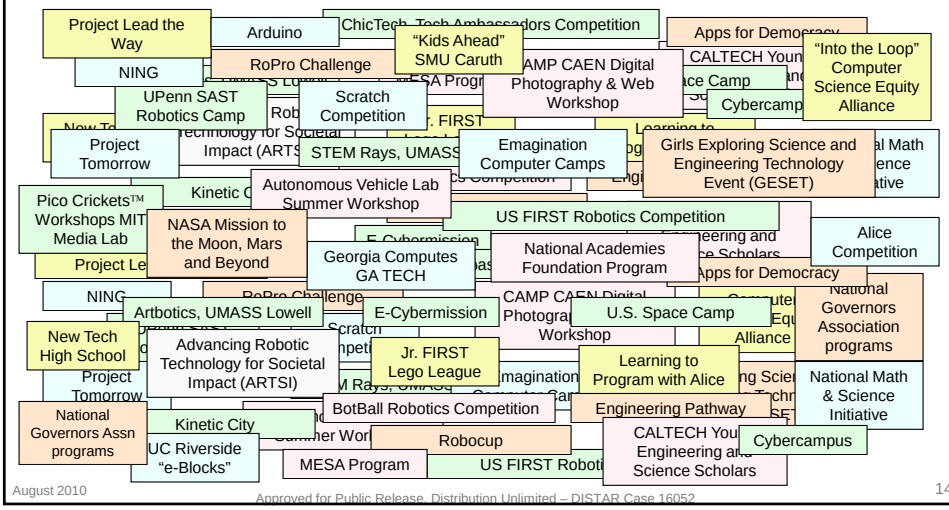
New York Times article, Nov 2008

- **Families and Engineering**
  - "A lot of the girls who were doing computer science came from families of computer scientists and engineers."
  - "It was in the air. There was the expectation that they could do whatever they wanted."
- **Focus on gaming**
  - "The girls game movement failed to dislodge the sense among both boys and girls that computers were 'boys' toys' and that true girls didn't play with computers."
  - "Some people in the field still believed that the answer to reversing declining enrollment was building the right game "
  - World of Warcraft has 30% women (according to womengamers.com)
- **Conclusion:**
  - We don't really understand why women aren't pursuing CS degrees

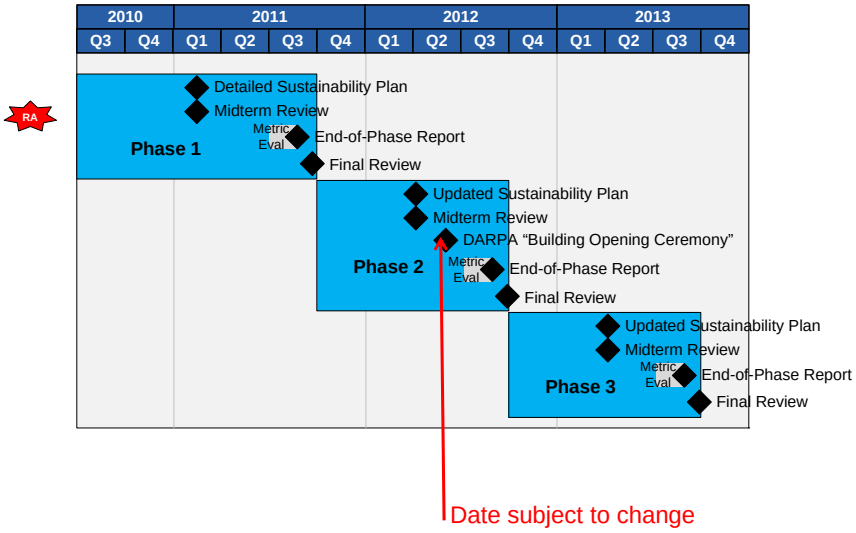
Thousands of programs exist to improve CS education

Many programs and events are effective locally, but:

- they lack systematic linkage to other programs
- they lack a national organizational structure to scale them up



Schedule



National Science Foundation

Preparing US Citizens for the Deluge Time to Get Going!

Joan Peckham
Program Director
NSF
OCI – Office of Cyberinfrastructure
Learning and Workforce Development

National Science Foundation

Computing & IT Education Needed

Technology and data touch everyone

- •Era of open government
- •Data exploration - 4th paradigm of science
- •Jobs – Well trained workers needed
- •Evidence based problem solving
- •From laptop concerts, to understanding the universe, and to protecting our nation's interests

We should not outsource our critical security needs.

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So what is the problem?

Change in need for well trained workers by 2018
Software engineers, programmers,

- Computer network systems and database administrators (+30%)
- Computer software engineers and computer programmers (+21%) (with programmers projected at -3%)
- Computer systems analysts (+20%)
- Computer, information scientists, and research (+24%)
- Computer support specialists (+14%)

Compare to engineering technicians decreasing or in the single digits and with engineers doing a tad better.

- Technicians(+5%) - Exceptions are civil engineering technicians (+17) and environmental engineering technicians (+30)
- Engineers (+10%) Highest are civil (+24%), environmental (+31%), biomedical (+72%)

Overall employment expected to increase by 20% in the same period

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Another Way to Look at It

Among the 20 fastest growing jobs through 2018, BLS finds:

- #2 - Network systems and data communications analysts (53% growth)
- # 15- Computer software engineers, applications (34% growth)

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Even the Military has Needs

As of Jan. 2009 – Of 1,226,460 Enlisted Employees (and 14 categories – 87,604 if evenly distributed)

- Electronic and electrical repair occupations 141,064
- Engineering, science, and technical occupations 151,028

Only others higher were:

- Combat specialty -193,503
- Transportation and material handling - 183,683

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What are we producing? CRA Taulbee Survey 2008-2009

Figure 6. BS Production (CS & CE)

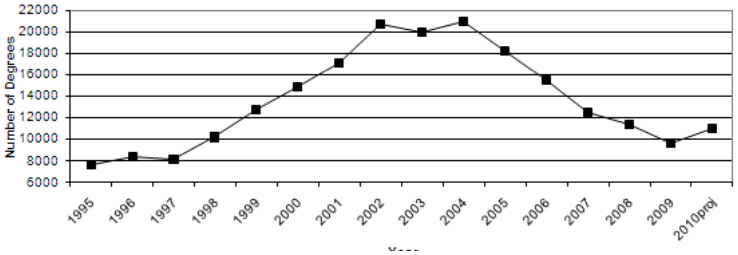
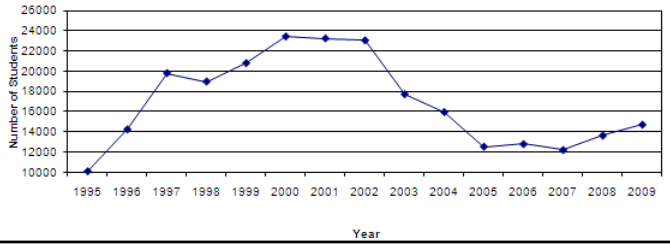


Figure 7. Newly Declared CS/CE Undergraduate Majors



National Science Foundation

The Role of Informal Learning

Recent NSF Funded Study – NPR, Oct. 2010

- Stronger And Smarter: Informal Science Learning In Rural American Libraries
  - Elementary-school children perform as well in science-understanding metrics as their peers
  - Middle- and high-school students perform abysmally
  - American adults demonstrate scientific knowledge on a par or above adults in other "developed" countries
  - 30% of adult Americans have ever taken even one college-level science course
  - Knowledge is acquired via what is called **informal science education** or **free-choice science learning**

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2009 Report of the National Academies on Informal Learning

- **Infancy - late adulthood: Learn about the world & develop important skills for science learning.**
- **A great deal of science learning, *often unacknowledged*, takes place outside school in informal environments.**
- **Learning in informal environments involves developing positive science-related attitudes, emotions, and identities; learning science practices; appreciating the social and historical context of science; and cognition.**
- **Informal environments can be particularly important for developing and validating learners' positive science-specific interests, skills, emotions, and identities.**

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How to Strengthen Informal Education With Rigor and Vigor

- Excitement, interest, and motivation to learn about phenomena in the natural and physical world.
- Generate, understand, remember, and use concepts, explanations, arguments, models and facts related to science.
- Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.
- Reflect on science as a way of knowing
- Participate in scientific activities and learning practices with others, using scientific language and tools.
- Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science.

-From the 2009 National Academies report on informal learning-

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Informal but Rigorous Computing & IT

How to inject the rigor?

Computational Thinking
•Core constructs of computing and computational science
•For everyone – citizen to scientist
•Fluency in the language of computing and our modern world – all disciplines

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Computational Thinking
What is it? What should we know?

Citizens and Scientists alike should know ...

- Animation of algorithms/processes
- Managing consequences of scale
- Error prevention - testing, debugging, recovery, and correction
- Data collection, archival, retrieval, exploration
- Step by step, interactive problem formulation, simulation, and solving
- Collaborative and plugged-in approaches

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Interactive Problem Solving
Intrepid Exploration

- Abstraction
- Breaking problems down into digestible parts
- Organized plug and play & debug
- And **Without Fear!**

Jill Denner –ETR Associates - Intrepid Exploration (Sherry Turkle) – CT for Everyone Workshop, February 4-5, 2009, National Academies

National Science Foundation

Computational Thinking Endgame for NSF

Research
- New mental tools
- New interdisciplinary efforts
- Innovation

Education
- Prepare the next generation
  - For computing
  - For new emerging disciplines
  - Strengthen existing disciplines
  - Stronger citizens, stronger nation

National Science Foundation

Preparing Citizens for the Deluge Time to Get Going!

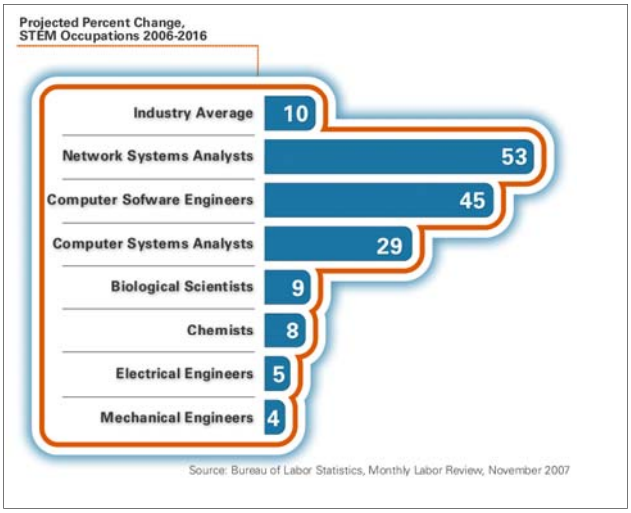
THANK YOU!

Transforming HS Computing Education

Jan Cuny
National Science Foundation
Oct. 18, 2010

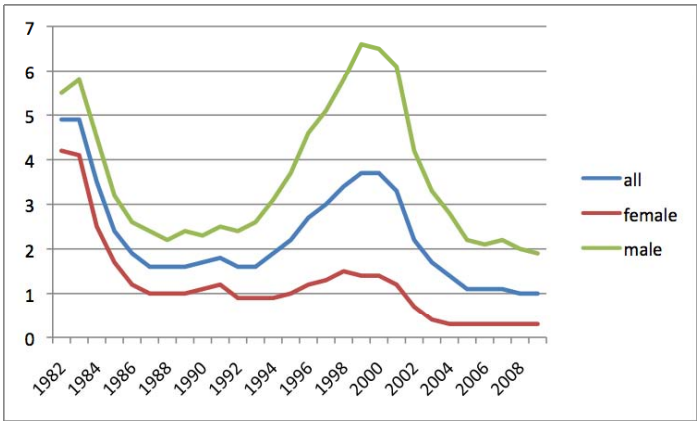
We have a problem in computing

Projected STEM job growth is in IT



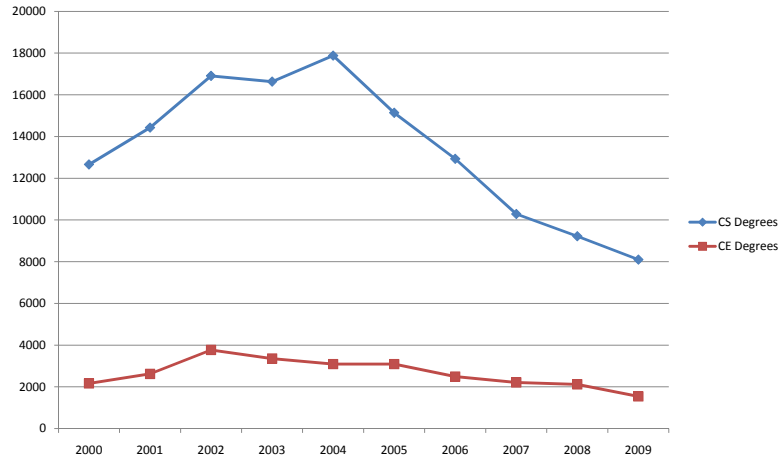
Slide: Dr. Chris Stephenson, CSTA, Data: BLS

% Freshman interest in CS



Source: HERI; Figure: NCWIT

Plummeting CS degrees



CRA Taulbee Survey, 2008-2009

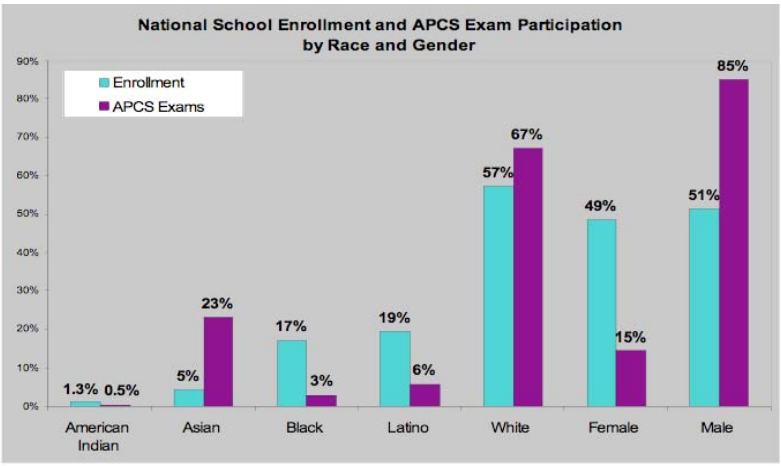
Underproduction

By 2018, there will be 1.4 million computer specialist job openings.

US universities will have generated enough graduates to fill about 1/3 of these openings.

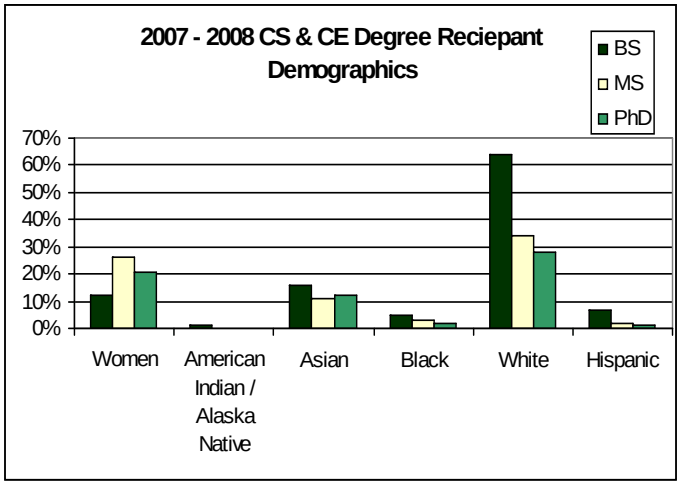
NCWIT, By the Numbers, 2009

The missing 70%



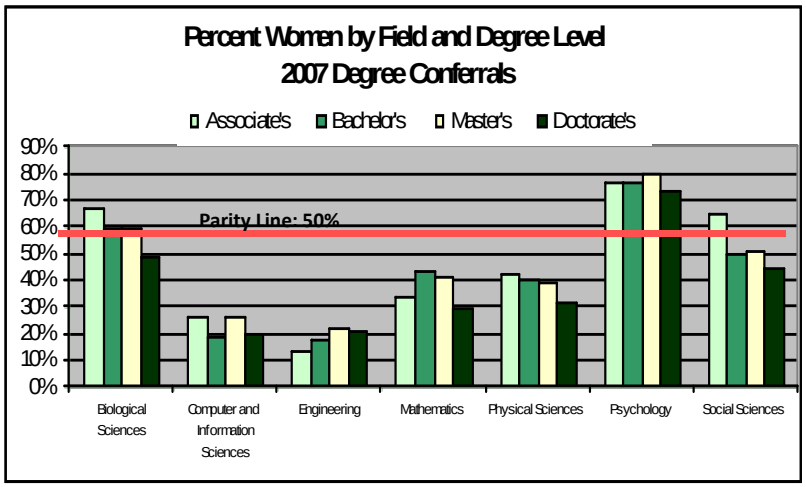
Slide: Dr. Chris Stephenson, CSTA, Data: College Board

The missing 70%



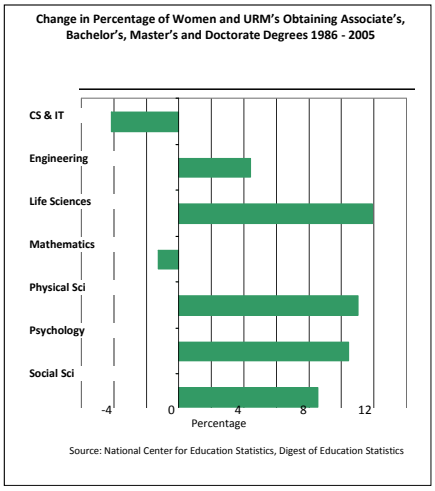
CRA Taulbee Survey, 2007/2008

How we compare



Source: Dr. Lisa Frehil, CPST

Trends in Underrepresentation



Source: National Center for Educational Statistics, Digest of Educational Statistics

Why does underrepresentation matter?

It's a loss of

- Opportunity for individuals
- Talent to the workforce
- Innovation and creativity to the field and to our economy

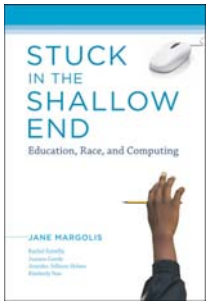
ACM Programming Contest

Place	Name
1	Shanghai Jiaotong University
2	Moscow State University
3	National Taiwan University
4	Taras Shevchenko Kiev National University
5	Petrozavodsk State University
6	Tsinghua University
7	Saratov State University
8	University of Warsaw
9	St. Petersburg State University
10	Zhongshan (Sun Yat-sen) University
11	Fudan University
12	KTH - Royal Institute of Technology
13	Ural State University

High school is the key to fixing it

Why High School?

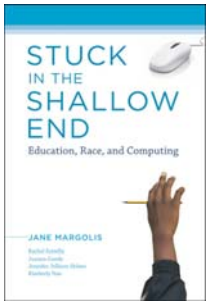
1. We need to do *much* better there.



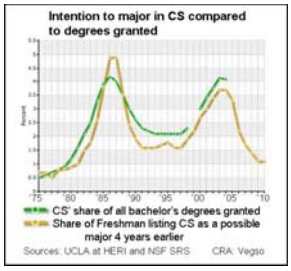
The state of HS CS

- Since 2005, introductory secondary school computer science courses have decreased in number by 17%, AP CS courses by 33%
- 2/3 of states have few computer science standards for HS
- Widespread confusion about technology education, literacy and fluency, and IT & CS as academic subjects
- Few states count CS in graduation core

Why High School?



1. We need to do *much* better there.
2. Without the HS piece, anything we do for middle school will be lost.
3. Without the HS piece, anything we do at the college level will be insufficient.



Why focus on AP?

CollegeBoard

- Often the only CS course that carries college prep credit
- Attractive to students & schools
- 2,000 CB-audited teachers
- Single point of national leverage

Proposed AP CS Principles

CollegeBoard

- Engaging, accessible, inspiring, rigorous
- Focused on the fundamental concepts of computing (CT)
- A target for K through 9 course development and an impetus for college curriculum reform
- Available nationwide with fidelity of replication

New High School Curriculum

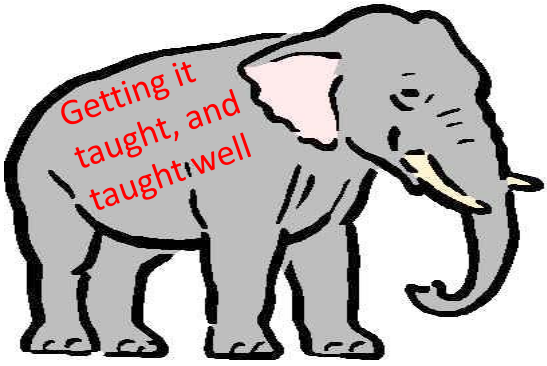
- Introductory course for everyone
- Proposed AP CS Principles
- AP CS Programming

ECS Team at LAUSD

AP CS Principles is a college course

2010 Pilots

- University of Washington
- UC Berkeley
- UC San Diego
- Metropolitan State College of Denver
- UNC Charlotte



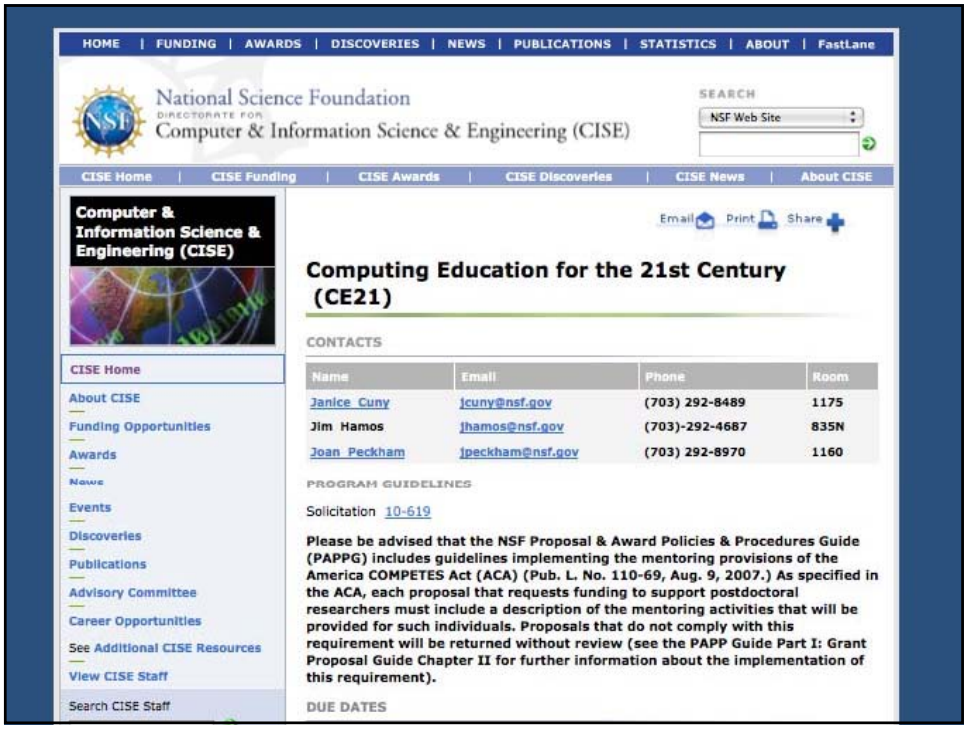
CS 10K

Develop an effective new high school computing curriculum and get it taught in 10,000 schools by 10,000 well-prepared teachers by 2015.

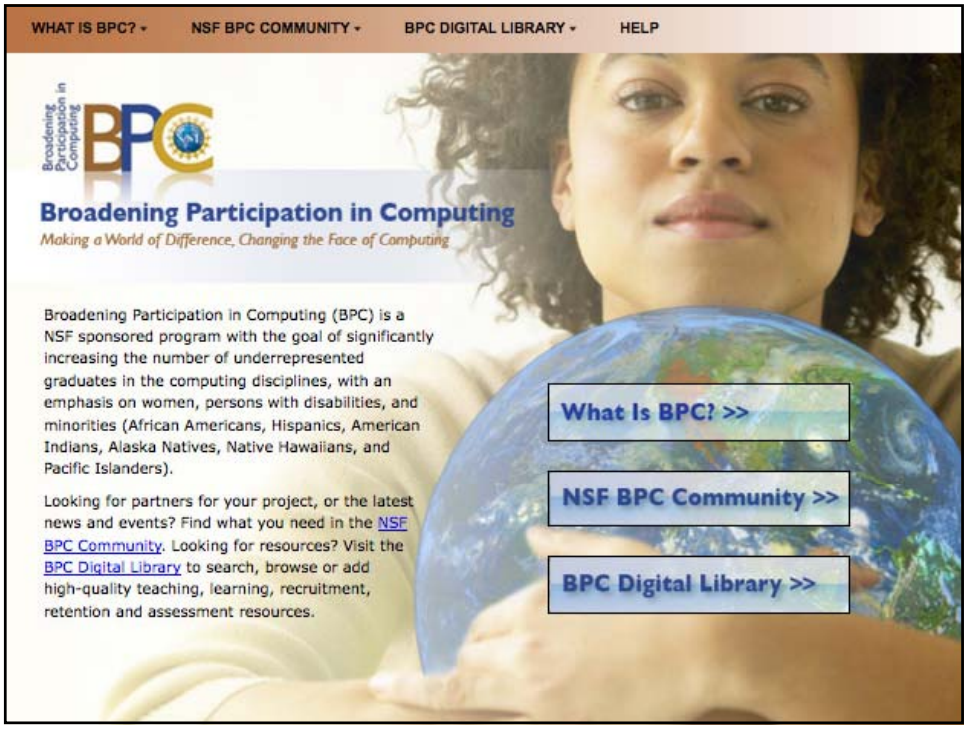
CS 10K Project

- Curriculum development
- Teacher Preparation
  - In-service preparation
  - Pre-service preparation
  - Ongoing professional development
- Entrée into schools

Needed: Public/Private Partnerships!!



Building momentum


WHAT IS BPC?
NSF BPC COMMUNITY
BPC DIGITAL LIBRARY
HELP
Broadening Participation in Computing
BPC
Broadening Participation in Computing
Making a World of Difference, Changing the Face of Computing
Broadening Participation in Computing (BPC) is a NSF sponsored program with the goal of significantly increasing the number of underrepresented graduates in the computing disciplines, with an emphasis on women, persons with disabilities, and minorities (African Americans, Hispanics, American Indians, Alaska Natives, Native Hawaiians, and Pacific Islanders).
Looking for partners for your project, or the latest news and events? Find what you need in the NSF BPC Community. Looking for resources? Visit the BPC Digital Library to search, browse or add high-quality teaching, learning, recruitment, retention and assessment resources.
What Is BPC? >>
NSF BPC Community >>
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We're young women with the power and passion to make a difference. We believe in the potential of computing to build a better world.
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Art & Art History
Astronomy & Space Exploration
Business
Communications
Computer Graphics & Media
Cooking
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Education
Engineering
Environment
Fashion & Design
Film, TV, & Theater
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Find out what we're all about.
The Webisode
Watch Dot Divas in action.
Become a Dot Diva
Here's how to get started.
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Tell your friends about Dot Diva
AIM
Send an email
Dot Diva on Facebook
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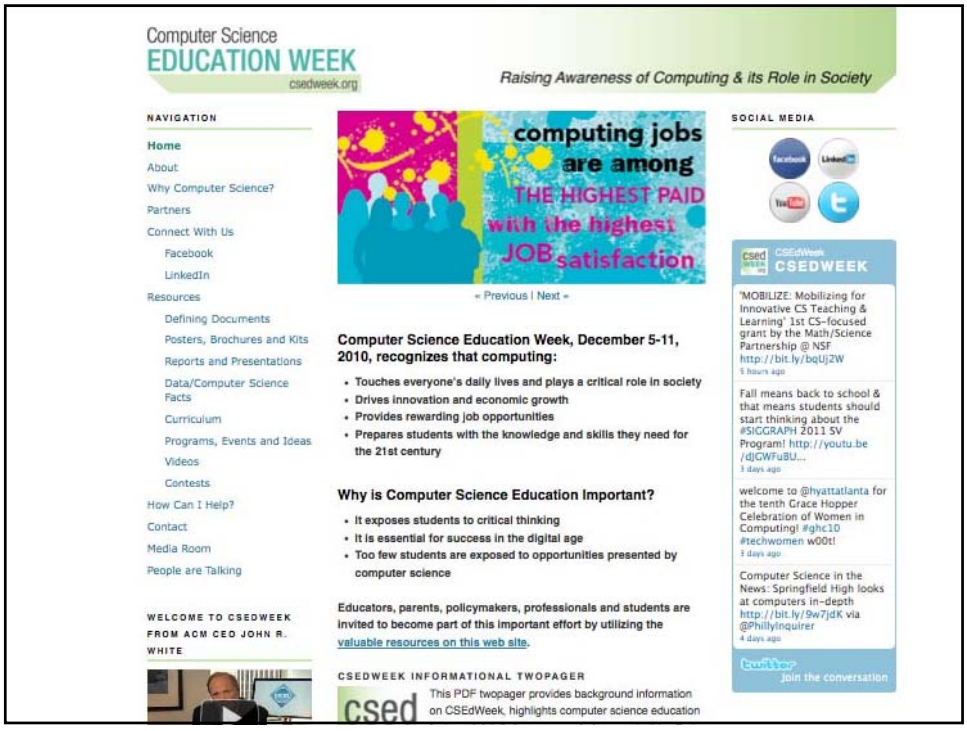
Bring Exciting Hands-On Learning to Your Area
It's more than just a day.
We're building a community.
JOIN NATIONAL LAB DAY
National Lab Day is a nationwide initiative to build local communities of support that will foster ongoing collaborations among volunteers, students and educators. Learn more.
Contact us with your successful NLD experiences. Please also visit our NLD Success page click here.
NLD Video Contest - Extended!
National Lab Day is hosting an online video contest. We want to see your projects!
The new deadline is October 1st.
The first place winner will receive a $1,500 DonorsChoose.org Gift Card and a Flip Video Camcorder.
NLD Photos see more »


Computer Science
EDUCATION WEEK
csedweek.org
Raising Awareness of Computing & its Role in Society
NAVIGATION
Home
About
Why Computer Science?
Partners
Connect With Us
Facebook
LinkedIn
Resources
Defining Documents
Posters, Brochures and Kits
Reports and Presentations
Data/Computer Science Facts
Curriculum
Programs, Events and Ideas
Videos
Contests
How Can I Help?
Contact
Media Room
People are Talking
WELCOME TO CSEDWEEK FROM ACM CEO JOHN R. WHITE
computing jobs are among THE HIGHEST PAID with the highest JOB satisfaction
« Previous | Next »
Computer Science Education Week, December 5-11, 2010, recognizes that computing:
Touches everyone's daily lives and plays a critical role in society
Drives innovation and economic growth
Provides rewarding job opportunities
Prepares students with the knowledge and skills they need for the 21st century
Why is Computer Science Education Important?
It exposes students to critical thinking
It is essential for success in the digital age
Too few students are exposed to opportunities presented by computer science
Educators, parents, policymakers, professionals and students are invited to become part of this important effort by utilizing the valuable resources on this web site.
CSEDWEEK INFORMATIONAL TWOPAGER
This PDF twopager provides background information on CSEdWeek, highlights computer science education
SOCIAL MEDIA
CSEDWEEK
'MOBILIZE: Mobilizing for Innovative CS Teaching & Learning' 1st CS-focused grant by the Math/Science Partnership @ NSF http://bit.ly/bqUj2W
Fall means back to school & that means students should start thinking about the #SIGGRAPH 2011 SV Program! http://youtu.be/dJCWFuBU...
welcome to @hyattatlanta for the tenth Grace Hopper Celebration of Women in Computing! #ghc10 #techwomen w00t!
Computer Science in the News: Springfield High looks at computers in-depth http://bit.ly/9w7jdK via @Phillyinquirer
Join the conversation

Thanks!

http://csprinciples.org
http://csprinciples.cs.washington.edu
http://www.computingportal.org/cs10k

Jan Cuny
jcuny@nsf.gov

DoD STEM Board member and Action Officer Summit - October 18, 2010

-- List of useful Website URLs – Page 1 / 2

- National Center for Women & Information Technology - http://www.ncwit.org
- "Stuck in the Shallow End: Education, Race, and Computing" by Jane Margolis

- http://mitpress.mit.edu/catalog/item/default.asp?ttype=2&tid=11550

- NSF Directorate for Computer and Information Science and Engineering - http://www.nsf.gov/cise/about.jsp
- NSF Broadening Participation in Computing (BPC) – http://www.bcportal.org
- Dot Diva – http://www.dotdiva.org
- http://picturemeincomputing.com
- Fostering Innovation Through Robotic Exploration – http://www.fire.cmu.edu
- Teach Ourselves - http://www.cs.arizona.edu/projects/focal/edinfo/teachourselves/

DoD STEM Board member and Action Officer Summit - October 18, 2010

-- List of useful Website URLs – Page 2 / 2

- Excelencia in Education – http://www.edexcelencia.org/
- National Lab Day – http://www.nationallabday.org
- Computer Science Education Week – http://www.csedweek.org
- NSF Office of Cyberinfrastructure - http://www.nsf.gov/dir/index.jsp?org=OCI
- National Public Radio – "Stronger And Smarter: Informal Science Learning In Rural American Libraries" - http://n.pr/9bxMiI
- DARPA Autonomous Robotic Manipulation – http://theARMrobot.com
- New York Times – "Widening Gap" - http://www.nytimes.com/2008/11/16/business/16digi.html?_r=1&em
- CS Principles - http://csprinciples.org & http://csprinciples.cs.washington.edu
- Connecting Computing Educators - http://www.computingportal.org/cs10k